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ABSTRACT

Advantages of the performance simulation setting are considered, along with what can be studied or developed within this setting. Experiences at the University of British Columbia (UBC) and views on future development and research opportunities in the performance simulation setting are also discussed. The benefits of simulating the clinical setting in preclinical training, with dental education as the point of reference, are addressed. Each unit for practicing dentistry is identical and the equipment design reinforces principles and philosophies of performance logic. Referenced positions of the model and standardized equipment provide a controlled environment that promotes research as well as observation of the student. The objective is to observe and analyze the interaction of all variables involved in the delivery of dental care to enhance performance. Developments at UBC and changes that have taken place since 1982 are discussed with attention to the following variables in the performance setting: instrumentation in the oral cavity, simulation of hard and soft tissues in the oral cavity, technical or physical support such as light sources and the dental students' seat, dental student characteristics such as posture and vision, standardization through the use of numeric language, and teaching techniques. (SW)

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PERFORMANCE LOGIC IN SIMULATION

RESEARCH AT THE UNIVERSITY OF BRITISH COLUMBIA

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I. INTRODUCTION:

Although the title of this presentation is "Research in Performance Simulation", I would like to expand that just slightly by including the word "development" because much of the associated research or stimulation that has come from the Performance Simulation Laboratory has led to developments with respect to teaching, physical equipment and control over the environment in general. Because our time is short, I would like to outline what I will try to present in the next 15 minutes.

Firstly, I would like to review the particular advantages of the Performance Simulation setting, the control that is available within that, and then ask two questions: 1) What can one study, research or develop in this particular setting? and 2) What have we done at the University of British Columbia and what changes have taken place as a result? Finally I would like to conclude with thoughts on future development and research opportunities in the performance simulation setting.

II. ADVANTAGES:

Simulated preclinical environments for dental education are not new. Teachers have always realized the benefit of trying to simulate the ultimate clinical setting in a preclinical environment in order that there is realism involved in the teaching of procedures and hopefully then to produce an ease of transferability from one environment to the other. Therefore, in

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that sense this simulation is not new, however, it does have particular advantages that other preclinical simulated settings have not enjoyed[1]. Dental simulation systems have varied from something as crude or as simple as a manikin head mounted on a pole on a bench, to what we are priviledged to have today in a rather sophisticated setting at the University of Maryland and the University of British Columbia. The entire environment has a feeling of realism and when students or teachers perform in the laboratory it is as though they were in the clinical setting. The arrangement of the instrumentation, the position of the patient's head and oral cavity and the operator positions are as they would be and could be in the clinic. Needless to say, students respond very favourably to this aspect of realism and, I believe, it contributes greatly to increasing and maintaining their motivation.

As you can see, this is a very controlled environment. There are certain ranges or restrictions that are imposed on movement, - for example, movement about the patient's head. There is only a certain amount of space within which the operator is free to move. This may seem to be a disadvantage but in fact it is a distinct advantage. Because of the physical arrangement you can also see that it is very easy for instructors to observe students operating at their own unit. Since each unit is identical, and as they are in a line, the observations can be more accurate, more comparative, and certainly more efficient. The equipment has been designed and produced in order to reflect and reinforce the principles and philosophies of performance logic. Within that philosophy there are referenced points. Since all of the units are identical and are built to meet these standards,

there are referenced positions within the system. Again, these can be easily identified and movements within these referenced positions or away from them can be easily observed and noted. In addition, the referencing allows specificity of instruction. One can use these referenced points to direct students in their approach to the working area. Overall the entire system provides a high degree of control. This control reduces the range of variability involved and allows us to ask specific questions whether they be educational or technical questions, and to investigate them with contaminating variables being either eliminated or significantly reduced. I am thinking of variables such as range of movement, where consistency and accurate reproducability become possible.

It's not to imply that research into specific questions, or development in certain areas could not happen in other environments. In this setting, however, it is easier because of the referencing, the ease of observation and the standardization of the equipment and the operator functioning within the dictates of the equipment. The circumstances have also stimulated more questions in our minds. Again not to say that it wouldn't have happened in another environment, but this particular setting is stimulating and gets people thinking about aspects in teaching and in development that can be more easily investigated.

III. WHAT CAN ONE STUDY, RESEARCH OR DEVELOP IN THIS ENVIRONMENT?

In our studies the objective is to observe and analyse the interaction of all the variables involved in the delivery of dental care with

a view to enhancing performance potential of all individuals that participate in that delivery of care. Therefore, in theory one could study any of those variables in this particular performance setting. For example:

1) the patient - the vertical height, and the factors related to the positioning of the operating site relative to the operator;
2) instrumentation in the oral cavity;
3) the simulation of hard and soft tissues in the oral cavity;
4) the technical or physical support - quality control and design;
5) the operator, - his posture, body height, vision;
6) numerics, - an application of numerical and digital language in a referenced setting;
7) teaching techniques, - ease in peer evaluation, communication, split half studies, etc.

IV WHAT HAVE WE DONE AT U.B.C.? WHAT CHANGES HAVE TAKEN PLACE SINCE 1982?

1. INSTRUMENTATION:

One of the research studies that we undertook very early in this preclinical setting, was to investigate the teaching of mirror vision to dental students[2]. Traditionally the introduction of learning how to prepare teeth to receive fillings has begun in the lower arch, or mandible, where direct vision can be used. This is based on the assumption that having to learn indirect or mirror vision skills in addition to fine motor skills only complicates that learning and creates barriers and obstacles for students. However, one difficulty with this particular approach is that universally indiviuals have had

problems with posture when moving from treatment of the lower arch to the upper arch as they continued to want to use direct vision rather than to learn how to use a mirror effectively. Therefore, we split our first year dental students into a treatment and control group and started half on the upper arch using mirrors and doing cavity preparations and started the other half on the lower arch using direct vision in the traditional method. Specific criteria were set and inter-relater reliability was establish. Through the study we had a number of tests and scored psychomotor skill performance in students' ability to produce cavity preparations. In addition, we set out to evaluate their posture using the referenced points in the system.

The results of the study revealed four things.

a) Posture was better for the arch in which students first began. Consequently if we believe that posture is important in the comfort, efficiency and longevity of a dental practitioner, then having equally good posture while working in the upper arch would be highly desirable.

b) There was an easier and more uniform transition from the upper to lower arch than vice versa. Students changing from lower arch to upper arch preparations did exactly what had been observed previously - they had problems with postural control for the upper arch preparations. Conversely those moving from the upper to the lower arch made with ease the transition from using a mirror to using direct vision.

c) At the end of the course there was no significant difference in psychomotor skill achievement in cavity preparation, i.e. those who began first to use mirror skills had not been disadvantaged.

d) When students were asked in hind sight, which arch they would prefer to begin their learning, the vast majority from both groups said that they could see benefit from beginning in the upper arch and if given the choice would choose to do so.

Therefore, as a result of this research study we have altered our first year teaching format and now all of our students begin their psychomotor exercises in the upper arch using indirect vision (learning the acquisition of mirror skills at the same time).

2. SIMULATION OF TISSUES.

At U.B.C. we have participated in field research in the testing of simulations of different tissues which could be used as teaching aids. We have been involved in "treating" teeth that have simulated enamel and simulated dentin layers. As well a new silicone-type material that is used as the gums of these manikins is being evaluated to determine if it responds like human tissue in surgical incisions and suturing. Currently under development are other tissues simulations that will be used to simulate more complicated oral surgery procedures, treatment in periodontal or gum disease, and the simulation of hemorrhage or bleeding into the working site.

3. TECHNICAL AND PHYSICAL SUPPORT.

In this area we have been very active in field testing components of

the simulation equipment and have been able to make modifications and improvements to the system. For example, the operator stool did not have enough movement in the vertical dimension to compensate for the range of upper body heights of individual students. The identification of this difference in upper body height led to an interim and early modification of the operator stool through the placement of a "jump seat" in order to boost those individuals with shorter upper bodies so that they could better visualize the working point in the oral cavity.

Not surprisingly, there were some complaints of operator discomfort associated with this particular seat. Following observation and extensive gathering of anthropometric data, modified design specifications were made to the manufacturer and a prototype was made and tested. Subsequently further modifications were made so that now we have the third edition which permits a wider but still guageable range of movement for the operator to optimally position himself relative to the patient. And as a bonus, he now has some extra padding to increase comfort!

Secondly, we have been involved in investigating light sources. The fixed light coming over the right shoulder is meant to provide feedback for students when they compromise their posture and lean into the field blocking out the light. However, it has created some problems in that the light source to the working area is not as bright as we would like it to be (approximately 1/2 to 2/3 of the lux of currently accepted standards of lighting in the oral field). Also the simulation isn't exactly as it would be in the clinic or in the dental office for I am sure you can remember the dental light usually comes from above and in front of the patient. Observation and student input is currently under review in this project.

Thirdly, the development of the handpiece pen which Dr. Rucker masterminded has been a tremendous addition to our teaching program. As I mentioned earlier, Dr. Rucker might have conceived this idea regardless of this particular setting, but perhaps the involvement that we had in the integration of the physical environment with our teaching program stimulated him to think of this idea earlier than he might have done. The handpiece pen is shaped just like the dental drill and provides that degree of realism or reality for students which, of course, they relate to very well. The nib on the pen simulates the cutting instrument that is used for cavity preparation and students can take the handpiece pen home with them and practice, with a mirror, their indirect vision skills, the grips associated with the handpiece, and become involved with refining their fine motor skills. It can be used outside of the laboratory setting which compliments and reinforces their active participation in the lab.

4. THE OPERATOR.

One of the other research activities undertaken has been investigation of visual acuity and preferred eye-object distance and its relationship to performance and posture in the preclinical setting[3]. The dental literature has supported the idea that the optimal operating focal length is 27 cm. - that is, the vertical distance between the inner canthus of the eye and the horizontal plane of the observed object. However, many dental settings demand longer focal lengths if tasks are to be performed without compromises to either vision or posture. Dr. Rucker took our first and second year classes and investigated their preferred focal length both in

free space and in a fixed setting. Two observations for each showed a high consistency of repeatibility of the preferred focal length in both conditions. The task involved counting the number of orange coloured dots presented in a random pattern ranging in size from 50 microns to a 1/2 mm. in diameter. Photos were taken and standardized to permit an accurate measurement of the preferred eye-object distance. In addition, the upper body height of each subject was measured and recorded - the reason being that in this fixed environment upper body dimensions greatly influence the demands on the setting adjustability in order to allow an optimal eye-object relationship for all operators. A person who is very tall may want to lean down to get closer to the working environment, whereas someone who is short in the upper body may have to lift or crane over the manikin head in order to be able to see adequately. Having a fully adjustable operator seat would eleviate this tendency.

Several observations of posture were taken during examinations and the results were correlated with psychomotor skill performance. The results of this research have shown the following:

a) There is such a wide range of preferred focal length that no single system could accommodate all individuals in a particular setting.

b) Students who had psychomotor skill performance grades in the lowest 25% of the class had a shorter preferred eye-object distance and those who performed in the highest 20% of the class had a longer preferred eye-object distance.

c) Those who were taller in the upper body had longer preferred focal distance and those who were shortest in the upper body had shorter preferred eye-object distance.

d) When posture and preferred focal distance were correlated there was a statistically significant difference between those with excellent posture and those with poor posture. Those with excellent posture had a longer focal distance, 27 cm., while those with poor posture had a 19.8 cm. focal distance. This would support the optimal distance cited in the literature. Therefore, it would seem that those with a longer preferred focal distance could function within the setting without having to compromise their posture or comfort. On the other hand, forced to operate in a different setting these individuals might have to compromise their posture in order to achieve that preferred focal length. Looking at the reverse side, those with shorter preferred focal distances are likely to want to move closer to the working site thereby jeopardizing their posture. If they don't compromise posture and comfort then they may be compromising by straining their eyes.

The results of this study further suggest that at least some students should be identified for optical adjustment if they are to perform psychomotor skills in the dental environment without handicap. The determination of the degree of handicap which requires optical intervention and the type of intervention is currently under further study.

5. NUMERICS.

Because references are fixed and are easily identified, the application of numerical sequences and the standardization of approach to the working area has allowed us to modify our teaching program and to reduce the amount of emperical experimentation that

students must go through in order to find the most efficient and effective working approach. The standardization through the use of the numeric language reduces time spent in experimentation and reinforces the concepts of performance logic.

6. CHANGES THAT HAVE BEEN BROUGHT ABOUT IN THE TEACHING PROGRAM.

I have already mentioned several of those changes in our discussions about research and development - i.e. all our students begin psychomotor skills training in the upper arch with the aid of a mirror, the use of the handpiece pen, the measurement of upper body height in order to adjust the operator working position, and the application of numerics in the teaching program. Beyond these things associated with the undergraduate teaching program this environment is perceived to be so realistic that we are able to conduct continuing dental education courses for our dental practitioners in the laboratory setting as though it were the clinic. Consequently, we can teach new techniques or refresh learning and techniques through the use of models and simulated tissues rather than having patients present for this form of activity.

V. FUTURE DEVELOPMENTS AND RESEARCH OPPORTUNITIES.

Now that certain disciplines in dentistry have integrated their teaching programs with this environment we expect there to be further expansion into other disciplines and the development of simulated tissues in order to support those areas - for instance periodontics, oral surgery, local anesthesia, etc. Therefore one could foresee that once others become

involved in this teaching setting additional initiatives and ideas would be stimulated for them, and activities could be taken which would provide new development and research opportunities in those areas. To further assist in the refinement of our teaching techniques, I would anticipate additional split half teaching technique comparative studies in the future and better definition of the measure of postural assessment. This is something that has not been undertaken previously and is an extremely important part of the delivery of dental care. We would hope to be able to bring about some refinement in that process and be able to more accurately assess and account for posture.

To date it has not been done, but we would like to investigate the transferability of the skills that are learned in the preclinical setting to the clinical environment. This would relate again to posture, to productivity and to comfort. And finally an assessment of the long term effect that the preclinical environment has on the graduate dentist - i.e. are the fine motor muscle memory sets that are established in the lab maintained through clinical training and then utimately in practice? Have graduates made decisions on equipment purchases or choices based on the parameters that were in place in the laboratory? In other words, would they choose a dental chair that has a moveable or hinged headrest rather than one with a fixed headrest?

VI. CONCLUSION.

Dental education as any process of learning must grow, experiment and learn from everything it attempts. Using sound principles of ergonomics we can begin to study, evaluate and evolve a systematic approach to the teaching of preclinical dental skills that will accelerate student learning and assist in the acquisition of psychomotor skills that are necessary for all dental operations. This performance simulation setting is an exciting teaching environment and one that is very conducive to student learning. It is expected that ultimately this approach will lead to a happier, healthier practitioner, one who can deliver quality dental health care in a more efficient manner, a goal, of course, that we have always set for ourselves and one which we are now closer to achieving.

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